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Comparing the Effects of Er:Yag Laser and Bur on Tensile Bond Strength of Single Step Adhesive System At Different Dentin Depths – An In Vitro Study.

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ABSTRACT

Background: The hard tissue erbium lasers have the capability to prepare enamel, dentin, caries, cementum and bone in addition to cutting soft tissue.The present study is aimed at evaluating the tensile bond strength a self etching restorative system, on superficial and deep dentin, after cutting the tooth with bur or Er:YAG laser. **Methods**: Sixty sound extracted human premolars were used in the study. These teeth were then randomly divided into two groups of thirty teeth each. Group 1- Bur cut, cut using diamond cutting disc and Group 2- Laser cut, cut using Er:YAG laser calibrated with 200mJ/10HZ/2.0W under 4ml/min water spray. These were then divided into two more subgroups of fifteen teeth as superficial and deep dentin sub groups. Specimens were coated with bonding agent followed by a microhybrid resin composite (SUREFILL,DENTSPLY). The specimens were then debonded in tension by mounting it on a universal testing machine (Instron Type 4204 Co.USA) and specimen SEM analysis of surfaces was done. **Results**: Bur cut superficial dentin showed maximum tensile bond strength (22.86 MPa) while bur cut deep dentin showed the least tensile bond strength (15.8MPa),Laser cut superficial dentin and deep dentin showed almost similar bond strength -19.18 MPa and 19.94MPa respectively. **Conclusion**: The superficial dentin produced better bond strength and results than deep dentin. Surface treatment by Er:YAG laser hampered the adhesion of self etching adhesive systems in both superficial and deep dentin.

Keywords: Dentin, Er:Yag Laser.

INTRODUCTION

Laser is an acronym for light amplification by the stimulated emission of radiation.

Laser was invented by Dr Maiman in 1960. Laser has found widespread application in Communications, industry, defense and medicine. Hard tissue lasers first developed in 1990's came to the dental marketplace in 1997.

These hard tissue erbium lasers have the capability to prepare enamel, dentin, caries, cementum and bone in addition to cutting soft tissue. The ability of hard tissue lasers to reduce or eliminate vibrations, the audible whine of drills, microfractures, and some of the discomfort that many patients fear and commonly associate with high speed hand pieces is impressive. In addition these lasers can be used with a reduced amount of local anesthetic for many procedures which makes hard tissue laser very exciting for needle phobic patients.[1]

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Although the first Er:YAG laser system (Kavo Key Laser, Kaltenbach and Voigt GmbH & Co., Biberach/Riss, Germany) was introduced into the medical market in Germany in 1992, it was not until 1997 that erbium lasers got approval for caries removal, cavity preparation and conditioning of the tooth.

Dentinal tissue continues to represent a challenge as regards bonding with resin-based adhesives, because of its complexity and dynamism. It is known that this composition may change according to the depth of tooth. This is due to the fact that superficial dentin has few tubules and is composed predominantly of intertubular dentin. Deep dentin (near pulp) is composed mainly of larger funnel-shaped dentinal tubules with much less inter tubular dentin.[2] The preparations produced by the Er:YAG lasers have a characteristically chalky surface when used on enamel. Scanning electron microscopic images show that laser irradiation produces a surface that increases the restorative material retention. The surface is ideal for the use of composite and compomer filling materials .Many studies have examined the ability of the erbium lasers to improve bond strength and marginal seal.

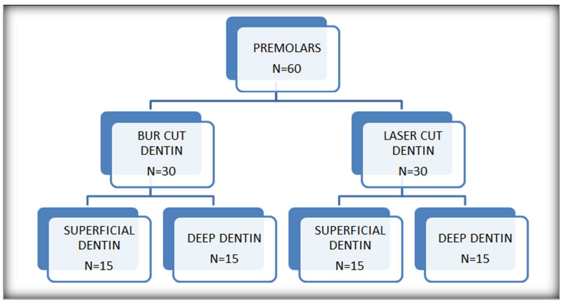
The literature available on the Er:YAG laser presents varying parameters and results, without clarifying whether such technique is really effective in improving adhesion, specially prior to the application of self-etching adhesives.[3] Taking all this into account, the present study is aimed at evaluating the tensile bond strength a self etching restorative system, on superficial and deep dentin, after cutting the tooth with bur or Er:YAG laser. The purpose of this study was:-

1) To investigate the tensile bond strengths of bur cut and Er:YAG laser ablated human dentin at different levels (superficial dentin & deep dentin) to composites with one step bonding systems.
2) To analyze the microstructure of laser ablated superficial and deep dentin.

MATERIALS AND METHODS

Sixty sound human premolars extracted within a six month period were collected and stored in distilled water. They were hand scaled and cleaned. Roots were cut 3-4mm from the apex with a diamond cutting disc.[2]

Teeth were then embedded horizontally with the buccal surface facing upwards in rectangular blocks of acrylic. These teeth were then randomly divided into two groups of thirty teeth each which were then divided into two more subgroups of fifteen teeth.



Sample preparation:-

Group 1 Bur cut dentin-

The teeth were cut parallel to the long axis of the tooth with a slow speed diamond cutting disc to remove the overlying enamel and to expose the most superficial dentin (approximately 1mm from the dentino enamel junction) using slow speed diamond cutting disc.

A demographic pencil was used to mark 2mm below the superficial dentin. This mark was taken as a guideline to expose the deep dentin. The teeth were cut using a slow speed diamond cutting disc exposing the deep dentin.[2] Teeth where pulp was exposed were discarded.

Group 2 Laser cut dentin-

The specimens were initially prepared by exposing the dentino enamel junction by using the diamond cutting disc. Specimens were prepared using Er:YAG laser calibrated with 200mJ/10HZ/2.0W under 4ml/min water spray. A non contact handpiece was used to cut the specimens and superficial dentin was exposed.

Similar to the bur cut specimens a 2mm mark was made after exposing the superficial dentin. The same laser settings were used to cut the tooth till deep dentin was reached.

The surfaces of all specimens were cleaned with water and air spray and the excess removed with absorbing paper, maintaining a damp surface. Self etch bonding agent Xeno V was applied uniformly over the dentin surface twice. It was gently air dried with air water syringe for 5 seconds. The sample was then light cured for 20 seconds using LED light.

A microhybrid resin composite (SUREFILL posterior composite DENTSPLY) was immediately bonded in increments of 1mm onto the prepared sample. The final specimen constituted of the tooth sample onto which a composite cylinder of 2mm diameter and 1cm height using a straw of the same dimensions, as a stent was bonded.

The specimens were then debonded in tension by mounting it on a universal testing machine (Instron Type 4204 Co.USA). The specimens were loaded at a crosshead speed of 1.0mm/min until the composite buildup separated from the tooth.

One tooth of each group was randomly selected for SEM examination of surface morphology. The specimens were dehydrated with ascending concentrations of 30-100% ethyl alcohol to facilitate gold sputtering of the samples. The sections were mounted on an aluminum stub and sputtered with gold (20-25µm). Specimens were then viewed under a scanning electron microscope (SEM) at a magnification of 5000X. The changes in surface morphology of dentinal tubules were seen and photomicrographs were taken.

RESULTS

While debonding the samples in a universal testing machine, no cohesive or tooth fractures were observed while debonding group 1 samples. On the contrary while debonding the laser group of samples one cohesive fracture (composite – composite) was observed whereas two tooth samples separated from the acrylic base.

Data was entered in Microsoft excel sheet and analysis was done by SPASS software Watson 16.

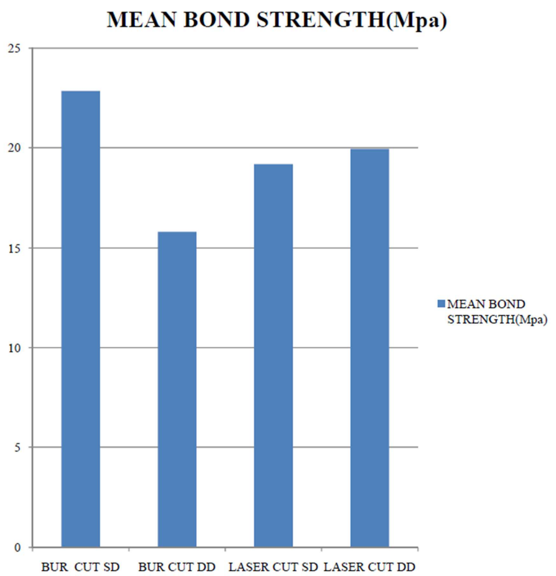
The data is expressed by mean and standard deviation and difference between the mean was observed by ANOVA followed by POST HOC test for multiple comparisons of the groups.

[Table 1] shows the Mean, SD, Minimum and Maximum value of tensile bond strength (MPa) of Laser + Bonding agent And Bur Cut + Bonding agent at different dentine Depth.

Bur cut superficial dentin showed maximum tensile bond strength (22.86 MPa) while bur cut deep dentin showed the least tensile bond strength (15.8MPa),Laser cut superficial dentin and deep dentin showed almost similar bond strength -19.18 Ma and 19.94MPa respectively. Graph 1 depicts the mean bond strengths of different dentin groups.

Table 1: Mean, SD, Minimum and Maximum value of tensile bond strength (MPa) of Laser + Bonding agent And Bur Cut + Bonding agent at different dentine Depth- Superficial Dentin and deep dentin

GROUPS	FREQ. (n)	MEAN	STD. DEVIA-TION	95% CONFIDENCE INTERVAL FOR MEAN		MIN.	MAX.
				LOWER BOUND	UPPER BOUND		
LASER CUT SD	15	19.18	1.26	18.48	19.88	16.77	21.52
LASER CUT DD	15	19.94	1.78	18.95	20.92	16.77	22.47
BUR CUT SD	15	22.86	3.11	21.14	24.79	17.66	28.48
BUR CUT DD	15	15.8	2.58	14.37	17.23	10.13	19.3
TOTAL	60	19.44	3.38	18.57	20.32	10.13	28.48



Graph 1: Mean Bond Strengths Of Different Dentin Groups

DISCUSSION

Stimulated emission from erbium ions in crystals of yttrium, aluminum and garnet was presented in 1975, preparing the pathway to a new laser called Er:YAG. Its emitted wavelength of 2940 nm matches exactly the maximal absorption of water, being about 15 times higher than the absorption of a CO2 laser and 20000 times that of a Nd:YAG Laser.[4] It is well absorbed in hydroxyapatite and effectively removes dentin and enamel with minor side effects such as thermal damage. It has been increasingly used in dental practice since its introduction in 1992.[5]

Histopathological and immunohistochemical pulp reactions show that Er:YAG laser preparation is not different from conventional tooth preparation. If a cavity comes close to pulp then a dentin bridge is formed. There are no signs of long term damage thus, Er:YAG laser can be considered as a safe treatment option.[6]

Marshall GW Jr et al,[7] stated that dentinal tissue is a challenge regarding bonding with resin based adhesives because of its complexity and dynamism. Deep dentin (near pulp) is composed mainly of larger funnel shaped dentinal tubules with much less intertubular dentin.[2] Not only the dentinal structures but water content varies according to the depth of dentin.

This was very much evident in our study in which bur cut deep dentin showed lesser bond strength than the bur cut superficial dentin, 15.8 and 22.86 MPa respectively.

A similar result was seen in a study conducted by Lopes GC et al[8] in which they compared the shear bond strengths of three simplified adhesive systems on superficial and deep dentin. When their data were pooled for dentin depth, deep dentin resulted in statistically lower bond strengths than superficial dentin (P<.01).

Dentin bonding agents contain reactive group which interacts with dentin and the monomer of the restorative resin. The seventh generation bonding systems (XENO V) act by forming a hybrid layer is prepared beneath the surface by partially or totally etching away of dentin, mineral crystallites, uncovering the collagen fibrils of the dentinal matrix and infiltrating adhesive monomer into that network to create a molecular level intertwining of biologic and artificial polymers. The structure is neither dentin nor resin so it is a hybrid of the two.

Cavity preparation alters the uppermost layer of tooth tissue. Research has confirmed that the resultant dentin surface for bonding depends on the preparation technique employed. Different instrumentation techniques can be applied to remove caries and to make the tooth surface receptive for bonding.

As the laser irradiation acts mainly on the hydrated part of hydroxyapatite, there is liberation of apatite which results in micro-crater like appearance.[9] Dentinal tubules are opened and the intertubular dentin is ablated to a greater extent than the peritubular dentin, due to high water and hydroxyapatite content of the former.[10]

The hybrid layer was not formed after laser irradiation because the dentin organic portion was not exposed, causing a subsequent decrease in bond strength.[11,10] This explains the fact that dentin treated by Er:YAG laser solely was totally unfavorable to the adhesion of resin. In our study also the laser ablated dentinal surfaces showed lesser bond strengths than the bur cut dentinal surface (19.18, 19.14 MPa and 22.86, 15.8 MPa respectively). But the laser ablated deep dentin showed higher bond strengths than the bur cut deep dentin which is in accordance with the study conducted by Aline Evangelista et al. Their resulting bond strengths were 10.40 and 9.60 MPa for laser ablated deep and laser ablated superficial dentin respectively.[3]

An earlier investigation done by Ramos et al,[11] in which the Er:YAG laser tooth surface was analyzed, drew the conclusion that this laser may adversely affect bond strength in higher or less degree, depending on the adhesive system used. It was noticed therefore, that the irregularities and fissures on dentinal surface after its application, are insufficient to provide adhesion of the material which is rightly evident in our study. In the scanning electron microscopic analysis where the micro structure of laser ablated superficial and deep dentin was examined, superficial dentin showed wider dentinal tubules than the deep dentin both being free of smear layer unlike the bur cut dentin.

CONCLUSION

Thus we conclude that superficial dentin produced better bond strength and results than deep dentin. Surface treatment by Er:YAG laser hampered the adhesion of self etching adhesive systems in both superficial and deep dentin as it produces irregularities and fissures on dentinal surface which is insufficient to provide adhesion for the material. Also, laser ablated deep dentin showed better bond strengths than bur cut deep dentin which is of clinical relevance.

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